INDOOR AIR QUALITY ASSESSMENT

Hiram L. Dorman Elementary School Annex
20 Lydia Street
Springfield, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
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Background/Introduction

At the request of Judy Dean, Western Massachusetts American Lung Association, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA), was asked to provide assistance and consultation regarding indoor air quality at the Hiram L. Dorman Elementary School (DES), 20 Lydia Street, Springfield, Massachusetts. On June 7, 2002, a visit was made to this school by Michael Feeney, Director of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA, to conduct an indoor air quality assessment. Mr. Feeney was accompanied by Ms. Dean during the assessment. Reports of inadequate ventilation, odors, lack of temperature control and other indoor air quality issues prompted the assessment.

The school consists of two separate buildings: the original building and the annex. The annex (DESA) is a two room, single story structure, built in 1954. The DESA contains two general classrooms and restrooms. Windows are openable. The original DES is a two-story red brick building and is the subject of a separate report.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

The school complex houses kindergarten through fifth grades with a student population of approximately 350 and a staff of approximately 30. The DESA contains two kindergarten classrooms with approximately 30 students and 4 staff. Tests were taken under normal operating conditions and results appear in Table 1.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were slightly below 800 parts per million parts of air (ppm) in both areas surveyed. Please note that classrooms had windows open and half occupancy during testing. Increased carbon dioxide measurements indicates that open windows alone are not sufficient to provide adequate ventilation. At the time of the assessment, the ventilation system in both classrooms was deactivated, which would limit the introduction of fresh air into the building and contribute to increased carbon dioxide levels. Due to the configuration and condition of the ventilation system, carbon dioxide levels in the building would be expected to increase over comfort levels during winter months when windows are closed.

Fresh air in the DESA is provided by a unit ventilator (univent) system of a design dating back to the original construction of the building (see Picture 1, Figure 1). Within each univent is a fan. In order for univents to function as designed, univent fresh air diffusers and return vents must be unblocked and remain free of obstructions. Importantly, these units must be activated and allowed to operate.

Both the radiator and univent were opened and examined in classroom 17. Airflow into the univent is controlled by a pendulum louver (see Picture 2). The position of the louver determines the amount of fresh to return air from the classroom. The louver in Picture 2 is fixed in the closed position, preventing fresh air intake by the univent.

Assuming that this univent is representative, the ventilation system is not able to draw fresh air from outdoors. The sole means for introducing fresh air into this building is through opening windows.

An exhaust vent exists in each classroom, which consists of a grill installed in a metal duct connected to recently installed rooftop exhaust vents (see Picture 3). Both classroom exhaust vents were operating.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last servicing and balancing was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix I.

Temperature readings (71^{o} F) were within the BEHA recommended comfort guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. Temperature control is difficult in an old building with abandoned or nonfunctioning ventilation systems. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measured in classrooms was 53 percent, which was also within the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Both classrooms, however, had relative humidity measurements 7 percent higher than the relative humidity measured outdoors (46%) on the day of the assessment. This increase in relative humidity can indicate that the exhaust system is not operating sufficiently to remove normal indoor air pollutants (e.g., water vapor from respiration) or that the exhaust ventilation is drawing moisture into the classrooms from a water reservoir. A possible moisture source exists from the drain system in the restrooms.

Limiting airborne moisture is important since the sensation of heat increases as relative humidity increases (the relationship between temperature and relative humidity is called the heat index). As indoor temperatures rise, the addition of more relative humidity will make occupants feel hotter. If moisture is removed, the comfort of the individuals is enhanced. Removal of moisture from the air, however, can have some negative effects. The sensation of dryness and irritation is common in a low relative humidity environment. Humidity is more difficult to control during the winter heating season. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

The design of the roof makes it prone to developing water leaks. The DESA has a flat roof covered with a rubber membrane. No roof drains appear to have been installed in the roof, nor does it appear that the roof has a pitch (see Picture 4). Water is allowed to accumulate on the roof. Once a certain amount of water has pooled, the excess spills over the roof edge into a gutter system. The accumulation of water on the roof can lead to premature wear and create leaks in seams during the freezing and thawing cycle during cold weather.

Water-damaged ceiling tiles were observed, which indicates a current or historic water penetration problem. Building staff reported an extensive water leak history from the ceiling in the building, which was alleviated with the installation of a new roof. Replacement of the ceiling tiles is difficult, since their removal appears to necessitate the destruction of the tile (see Picture 5), which can result in the aerosolization of particulates. Water-damaged ceiling tiles may provide a medium for mold and mildew growth and should be replaced after a water leak is discovered and repaired.

A pungent mold odor was detectable in the back of room 17. The odor was traced to the closet, which contained a bucket with standing water and a wet mop. A heavy coating of biofilm (microbial growth) was noted within the mop bucket (see Picture 6). Once this bucket was removed from the restroom, the intensity of the pungent odor decreased, but was not eliminated. Both standing water and wet mops can serve as mediums for mold growth. Mop buckets should be emptied and dried after use. Mop heads should be dried as soon as practicable to prevent mold growth.

Other Concerns

A number of other conditions that can potentially affect indoor air quality were also observed. Another possible source of odor detected in the rear of room 17 is the floor drain and sinks within the restrooms. Staff reported that restroom sinks are not used (see Picture 7). In addition, the floor drain traps of the restrooms appeared to be dry. A trap forms an airtight seal when water is poured down the drain. A dry trap can allow for sewer gas to back up into the building. Sewer gas can be irritating to the eyes, nose and throat. After water was poured into the floor and sink drain, the pungent odor dissipated. Without a wet trap, the depressurization created by the exhaust ventilation system can draw air from the drainpipes and connected sewer system.

Univents did not contain filters, despite the presence of a filter rack (see Picture 2). The interiors of both the univent (see Picture 8) and radiator (see Picture 9) are coated with accumulated dust, dirt and other debris. In order to avoid serving as a source of aerosolized particulates, the air handling sections of the univents should be regularly cleaned. However, without filters, dirt, dust and debris can easily collect within the units. In this condition, dust, dirt and other debris can be introduced/re-aerosolized by the ventilation system. In order to decrease aerosolized particulates, disposable filters with a high dust spot efficiency should be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent would be sufficient to reduce airborne particulates (Thornburg, 2000; MEHRC, 1997; ASHRAE, 1992). Note that increased filtration can reduce airflow produced by the unit due to increased resistance (called pressure drop). Prior to any increase of filtration, each univent should be evaluated by a ventilation engineer to ascertain whether it can maintain function with higher efficiency filters.

Conclusions/Recommendations

The conditions noted at the Dorman Elementary School Annex raise a number of indoor air quality issues. The combination of poor maintenance of the HVAC system, dry traps and lack of filters within the HVAC system, if considered individually, present conditions that could degrade indoor air quality. When combined, these conditions can serve to further negatively affect indoor air quality. Some of these conditions can be remedied by actions of building occupants. Other remediation efforts will require alteration to the building structure and equipment. For these reasons a two-phase approach is required, consisting of **short-term** measures to improve air quality and **long-term** measures that will require planning and resources to adequately address the overall indoor air quality concerns.

The following **short-term** measures should be considered for implementation:

1. Do not store mops in standing water. Drain and dry mops and mop buckets after use. Discard moldy mop heads.
2. Pour water into the sink and floor drains twice a week to maintain the airtight seal.
3. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the restoration of univent fresh air control dampers throughout the school.
4. Remove all blockages from univents to ensure adequate airflow. Clean interiors of univents regularly.

5. Clean accumulated debris from exhaust vent louvers.
6. To maximize air exchange, the BEHA recommends that the ventilation system operate continuously during periods of school occupancy independent of classroom thermostat control.
7. Once both the fresh air supply and the exhaust ventilation are functioning, the ventilation system should be balanced.
8. Supplement airflow in classrooms by using openable windows to control for comfort. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.
9. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

The following **long-term measures** should be considered:

1. Considerations should be given to installing roof drains in the center of the largest amount of water accumulation on the roof. If not feasible, building a pitch into the level of the roof to aid drainage when roof is replaced.

2. Water-damaged ceiling tiles should be replaced. These ceiling tiles can be a source of microbial growth and should be removed. Sources of water leaks (e.g., window frames and roof) should be identified and repaired. Examine the non-porous surface beneath the removed ceiling tiles and disinfect with an appropriate antimicrobial.

References

ASHRAE. 1992. Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 52.1-1992.

BOCA. 1993. The BOCA National Mechanical Code-1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL. M-308.1

MEHRC. 1997. Indoor Air Quality for HVAC Operators & Contractors Workbook. MidAtlantic Environmental Hygiene Resource Center, Philadelphia, PA.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

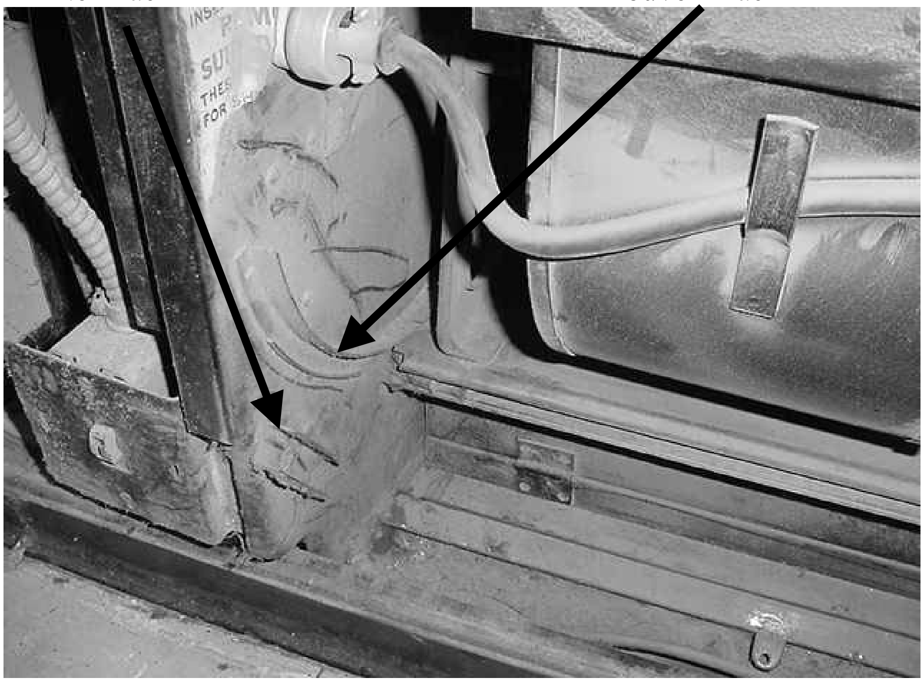
Thornburg, D. 2000. Filter Selection: a Standard Solution. *Engineering Systems* 17:6 pp. 74-80.

Picture 1

DESA Univent

Picture 2

Filter Rack Louver Track



Pendulum Track For Louver, Note Filter Frame Stays of Cabinet Wall

Picture 3

Exhaust Vents On DESA Roof

Picture 4

Accumulated Water On DESA Roof, Note Dry Gutter At Edge Of Roof Indicating Minimal Drainage

Picture 5

Ceiling Tiles Adhered To Ceiling In DESA

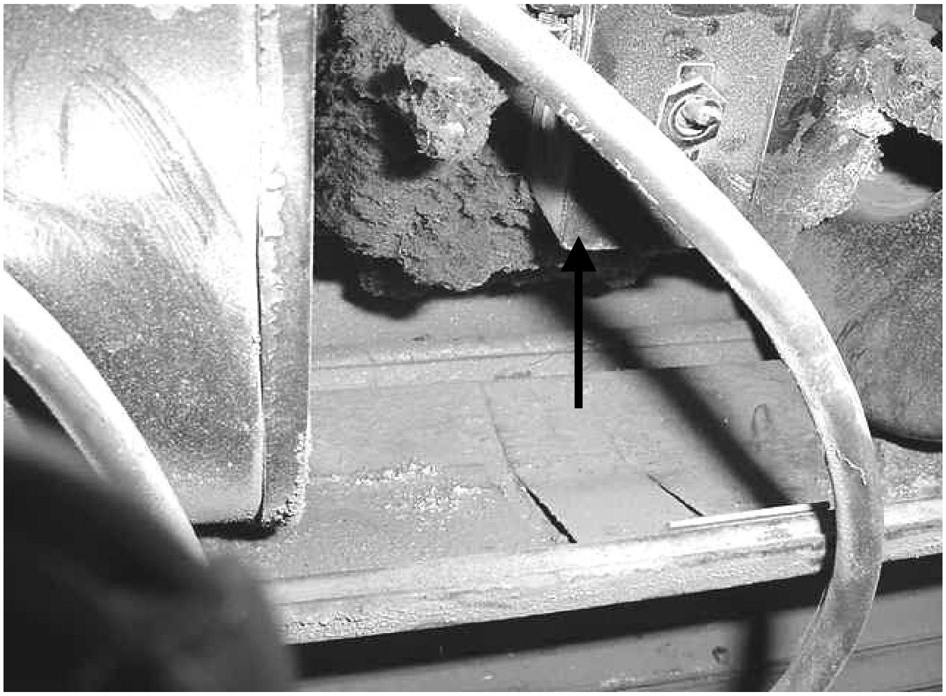
Picture 6

Interior of Bucket Stored in Room 17

Picture 7

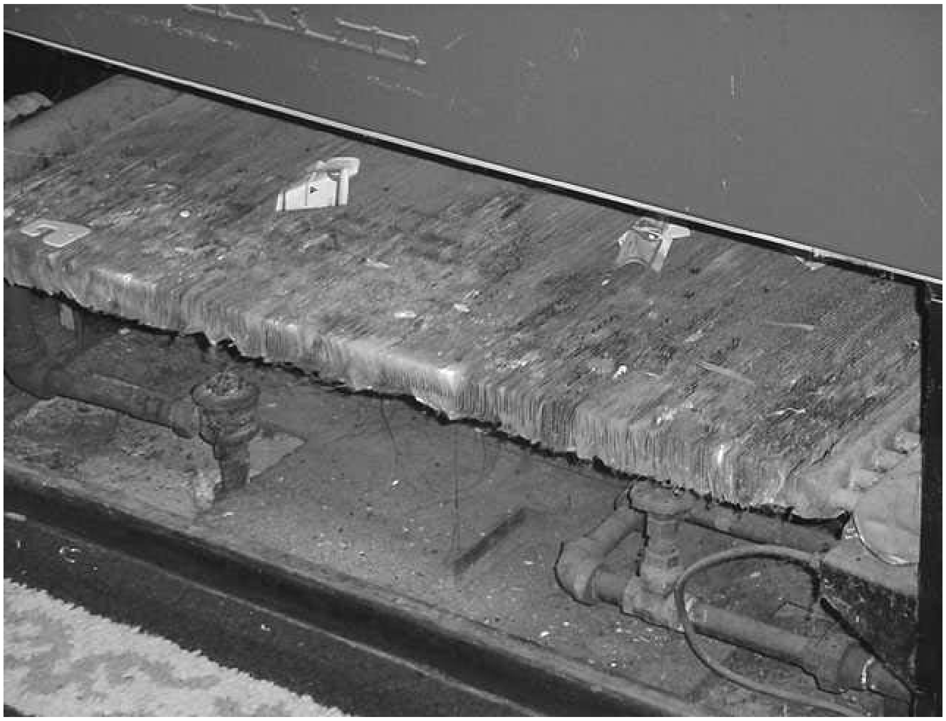
Materials Stored On Room 18 Restroom Sink

Picture 8



Accumulated Dust on Motor for Fans Inside Univent of Room 17

Picture 9



Radiator Coils Inside Cabinet of Room 17

TABLE 1

Indoor Air Test Results –Dorman Elementary School, Annex Building, Springfield, MA – Springfield, MA
June 6, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	425	64	46					
Room 17	703	71	53	1	yes	yes	yes	univent off-no filter-dust accumulation in interior, sewer odor-dry traps
Room 18	716	71	53	15	yes	yes	yes	univent off, window open, mop in standing water, dry traps

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%